CLAIMS

What is claimed is:

1. In a vertical cavity surface emitting laser (VCSEL) comprising vertically stacked material layers including a first material layer positioned above a second material layer, an intermediate region being disposed therebetween, electrical current flowing between the first material layer and the second material layer through the intermediate region during operation of the VCSEL, a current confinement structure for laterally restricting the flow of electrical current passing through the intermediate region, comprising:

a central column of semiconductor material vertically extending between the first and second material layers;

a subsurface cavity laterally circumscribing said central column of semiconductor material and vertically extending between the first and second material layers, said subsurface cavity being filled with a non-solid material; and

an outer support element laterally surrounding said subsurface cavity, said outer support element comprising a non-conducting material, said outer support element mechanically supporting said first and second material layers in conjunction with said central column of semiconductor material, the electrical current being laterally confined to said central column while passing from the first layer to the second layer.

2. The current confinement structure of claim 1, the VCSEL having a plurality of upper material layers positioned above said first material layer, further comprising at least three vertically etched shafts extending downward from a top surface of said upper material layers to said subsurface cavity.

3. The current confinement structure of claim 2, wherein said vertically etched shafts are plugged such that said subsurface cavity is sealed.

4. The current confinement structure of claim 3, wherein said non-solid material is air or vacuum.

5. The current confinement structure of claim 3, wherein said non-solid material comprises an inert gas.

6. The current confinement structure of claim 3, wherein said vertically etched shafts are plugged with a polyamide sealer.

7. The current confinement structure of claim 1, said outer support element and said central column being formed from a common layer of semiconductor material, said outer support element being implanted so as to be non-conductive.

8. The current confinement structure of claim 7, said first material layer and said upper material layers being implanted in lateral regions thereof lying above said outer support element.

9. The current confinement structure of claim 8, the VCSEL having a plurality of lower material layers positioned below the second material layer, said second material layer being an active layer, wherein electrical current flowing through the second material layer to the lower material layers is substantially confined to a lateral area corresponding to a lateral extent of said central column of semiconductor material.

10. The current confinement structure of claim 8, said first material layer being an active layer, wherein electrical current flowing through the first material layer to the second material layers is substantially confined to a lateral area corresponding to a lateral extent of said central column.

11. The current confinement structure of claim 8, wherein said common layer of semiconductor material forming said central column and said outer support element comprises an oxidation-resistant, low-bandgap semiconductor material.

12. The current confinement structure of claim 11, said common layer of semiconductor material being InGaAs or InGaAsP.

13. The current confinement structure of claim 12, the VCSEL having a plurality of lower material layers positioned below the second material layer, said second material layer being an active layer, wherein said upper material layers comprise a distributed Bragg reflector (DBR), wherein said first material layer is a p-doped semiconductor layer, and wherein said lower material layers comprise a DBR.

14. A vertical cavity surface emitting laser (VCSEL) formed from a vertical stack of substantially flat material layers, comprising:

an active layer disposed between a first set of material layers thereabove and a second set of material layers therebelow, electrical current flowing between said first set and said second set of material layers during operation of the VCSEL; and

a current confinement layer positioned substantially adjacent to said active layer, said current confinement layer being partitioned into a central current confinement zone comprising a semiconductor material and an outer support zone comprising an implanted semiconductor material, said central current confinement zone being separated from said outer support zone by a subsurface cavity laterally circumscribing said central current confinement zone, the electrical current flowing through said active layer only in a laterally extending area substantially corresponding to said current confinement zone of said current confinement layer.

15. The VCSEL of claim 14, at least three vertically etched shafts extending downward from a top surface of said first set of material layers to said subsurface cavity, wherein each of said first set of material layers remains laterally integral over said central current confinement zone, said subsurface cavity, and said outer support zone at locations other than said vertically etched shafts.

16. The VCSEL of claim 15, wherein said vertically etched shafts are plugged such that said subsurface cavity is sealed.

17. The VCSEL of claim 16, wherein said subsurface cavity is filled with air, vacuum, or an inert gas.

18. The VCSEL of claim 16, wherein said vertically etched shafts are plugged with a polyamide sealer.

19. The VCSEL of claim 14, wherein said semiconductor material of said current confinement layer is oxidation-resistant.

20. The VCSEL of claim 19, wherein said semiconductor material of said current confinement layer is a low-bandgap semiconductor material.

21. The VCSEL of claim 20, wherein said semiconductor material of said current confinement layer is InGaAs or InGaAsP.

22. A method of fabricating a current confinement structure into a partially-constructed VCSEL, said partially-constructed VCSEL having an active layer disposed between an upper set of material layers thereabove and a lower set of material layers therebelow, said partially-constructed VCSEL further comprising a current confinement layer positioned below the upper set of material layers and immediately above the active layer, comprising:

forming at least three hollow vertical shafts extending downward from a top surface of the upper set of material layers to at least a bottom of the current confinement layer, the vertical shafts being laterally positioned outside a desired current confinement zone; and

etching with a selective etchant that laterally etches the current confinement layer substantially faster than it etches any of the upper material layers and substantially faster than it etches the active layer, the current confinement layer thereby being etched away outwardly from an axis of each vertical shaft so as to form a subsurface void around each hollow vertical shaft at the current confinement layer, said etching continuing until the subsurface cavities merge together to form a single subsurface circumferential cavity around the desired current confinement zone.

23. The method of claim 22, further comprising, prior to said forming the at least three vertical shafts, implanting said upper material layers and said current confinement layer in lateral areas lying outside the current confinement zone.

24. The method of claim 23, further comprising subjecting the partially-constructed VCSEL to a predetermined surrounding environment while sealing off the hollow vertical shafts, said predetermined surrounding environment being sufficient to cause the subsurface circumferential cavity to contain a non-solid selected from the group consisting of: air, vacuum, and inert gas.

25. The method of claim 24, wherein the hollow vertical shafts are sealed off with one or more sealing materials selected from the group consisting of: a polyimide material, a metallization material, and a dielectric material.

26. The method of claim 22, wherein $M > 2$ hollow vertical shafts are formed, the hollow vertical shafts being spaced in a roughly circular arrangement outside of the desired current confinement zone and being angularly separated by roughly 360/M degrees around a center of the roughly circular arrangement.

27. The method of claim 26, wherein the number M of hollow vertical shafts is equal to 4.

28. The method of claim 22, wherein the current confinement layer comprises an oxidation-resistant material.

29. The method of claim 22, wherein the current confinement layer comprises a low-bandgap semiconductor material.

30. The method of claim 22, wherein the current confinement layer comprises InGaAs.